A Multi-Viewpoints Trust Model in Online Auction

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***Abstract*- Developing a multi-viewpoints trust model mainly for the problems existed in the current assessment of trust degree in online auctions. Referencing to various activities of online auctioneers and bidders, the model divides the participants into bidder, auctioneer and the third party/auction websites. Different participants in online auction have different parameters on the trust computation, such as the recent credibility, the time weight, the value of the transaction, the reputation feedback, the behavior analysis, etc. By means of evaluating the assessments of trust degree with multi-viewpoints of different participants, we calculate credibility of participants separately. The multi-viewpoints trust model is able to greatly improve the accuracy of calculation. Furthermore, it is more effective for analyzing the trust degree in online auction.**

Keywords- Online Auctions; Multi-Viewpoints Trust Model; Trust Degree; Reputation Assessment; Reputation Feedback; Behavior Analysis

I. INTRODUCTION

With the development of Web technology, e-commerce becomes a new driving force for economic development. As a main branch of e-commerce, online auction is booming rapidly. Unlike traditional ones, online auction breaks the territorial limits and expands the scopes of transactions. On the other hand, it has encountered a bottleneck for further development for that the participants may not make deals face-to-face. In other words, there exists a serious trust deficit due to the space-time separation. This problem has been attractive to many experts and scholars. The reports of the Internet Fraud Complaint Center (IFCC) indicate that online fraud happens more in auction websites, accounting for 44.9% of complaints, most of which (19%) are caused by nonperformance of sellers' delivery obligations by the sellers after the tender. Fraud behavior from different perspectives runs through the online auction process. From the seller (tenders) behavior point of view, fraud behavior can be divided into: No Delivery of Goods, False Description, Inflated Costs, Shill Bidding, Sale of Illegal Productions, etc.; and the buyer (bidder) will mainly take the following fraudulent means: Multiple Bidding, Collusion Bidding, Non-payment, Refund Scares, Shade Bidding, etc.; while auction sites may also be involved in conspiracy to commit fraud, mainly reflected in: False Advertising, False Description, etc. [1]. It shows that trust has become a vital factor for the development of online auction. Therefore, it is an important and urgent issue to create a reasonable trust model for the future of e-commerce.

Though research on trust model in the field of online auction has proliferated in recent years, effort in analyzing related factors, especially the multi-viewpoints, is lacking. Details on current trust model and existing defects are discussed in later sections.

To address the problem of user reputation evaluation in online auction, a multi-viewpoints trust model is proposed. This will be followed by a description of the multi-viewpoints trust model of the problem and a detailed presentation of how to realize the trust model.

II. THE CURRENT TRUST MODEL

Currently, eBay, Yahoo and other auction websites adopt kind of accumulative or a simple averaging approach to evaluate credibility of the users. This kind of trust model is namely to cumulate all reputation feedback of a specific user and to find out his/her overall credibility [2]. The cumulative trust model is widely used in Taobao, eBay and most other auction websites. The model can be expressed as:

$$R_n = R_{n-1} + r_n, r_n \in \{-1,0,1\} \tag{1}$$

Use of recursion available:

$$R_n = R_0 + \sum_{i=1}^{n} r_i \tag{2}$$

Among them, R_0 is the user's initial trust. R_n, R_{n-1} are the *n*-1th and *n*th cumulative reputation feedback score. r_i is the *i*th reputation feedback score, and $r_i \in \{-1,0,1\}$.

Average trust model is mainly to sum up all the reputation feedback and divide it by evaluation times. The outcome is recorded as the user's overall credibility [2]. Amazon and some other auction websites adopt this model currently.

This kind of model is applicable to wider scopes, originally. However, its ability of distinguishing situation is not good enough, since it ignores a number of objective factors occurring in the transaction of online auctions. Thus the user credibility status cannot be fully and accurately assessed due to disregarding the multi-dimension of credibility.

Based on the foundational cumulative and averaging methods, many researchers and technicians proposed a variety of theoretical trust models, such as: sociological theory-based trust model, statistics-based trust model, probability-based trust model , semantic-based trust model, uncertainty theory-based trust model and grid-based trust model .

A. Sociological Theory-based Trust Model

Based on sociological theory-based trust model [3], the typical representative is Marsh model. From 1994, the scholar Marsh started to research trust, through drawing lessons from psychology, sociology of computing trust ideas. This paper proposed a distributed artificial intelligence environment in computable trust models. The model itself is built on the trust of trust and social attributes, and is divided into basic trust, general trust and situational trust, the behavior of the importance and usability is process for quantification and classification, and calculates trust degree by the trust agent.

B. Statistics-based Trust Model

In order to overcome the existing drawback of trust model, a lot of experts use eBay trust model for example. Applying the statistics theory, it proposed statistics-based trust model. More typical of all the models are: Sporas trust model [4] and Malaga trust model [5]. Sporas trust model is proposed by Zacharia which is according to the existence of the problem of eBay trust model. The trust calculation method is improved in an iterative computational model of trust. This model first noticed the new user credit problem, and the initial trust is set to the system of minimum confidence, avoid malicious users to discard the old identity in replacement of identity fraud which may continue to implement. Secondly, participates the weight by the trust, credibility high rated the score weights more than the credibility of high weight low participating. Finally, for the high credibility of the participating, the trust will increase to slow down, to avoid trust unlimited growth. Malaga trust model is on average improvement trust model. In a word, Malaga trust model is improved average value trust model.

C. Probability-based Trust Model

Many scholars take example from psychology, sociology and other disciplines of the trust concept, use a probabilistic approach to describe the trust degree, and propose a lot of probability-based trust models, in which the typical model is Mui model [6], Jøsang trust model [7] and Beth trust model [8].

D. Semantic-based Trust Model

Semantic-based trust model is to use semantic variables to describe trust between users. One of the most representative models is Abdul-Rahman trust model [9]. Abdul-Rahman, according to the characteristics of social trust to classify the trust language based on semantic, proposes the trust model facing virtual community and based on social reputation mechanism. The model using only four simple semantic variables to represent trust, which is difficult to accurately describe the trust multidimensional nature and subjectivity: In the calculation of trust, they only take user's and tester's semantic distance into account, but they ignore the recommender trust, which cannot solve the malicious recommendation trust people's negative impact. Model itself emphasizes conditional transfer of trust, and gives a specific transmission protocol and formula, but does not give a specific formula of trust, and also does not explain the direct access method and meaning of existence, making the model have different degrees of the defect.

E. Uncertainty Theory-based Trust Model

Currently, there are scholars who use uncertainty theory-based trust model to derive trust between users, the typical model for Yu trust model [10]. According to the trust propagation mechanism in the real world, Yu used evidence measure thinking in Demspter-Shafer theory of evidence to propose trust model based on social reputation mechanism. The model is based on Dempster-Shafer theory of evidence in the definition of the function of trust, the trust path synthesis using synthesis rules on the recommendation trust information to calculate the trust.

F. Grid-based Trust Model

As grid technology is a relatively new hot technology, the current grid-based trust model [11] has less research. Grid is the grid entity according to their respective organizations, geographic location, etc into several different independent self-governing domains and for each domain to take the appropriate self-management strategies and security policies between autonomous domains to connect to the network. The trust model based on this theory is more scalable, heterogeneous platform compatibility, simplicity, and so on. A typical grid-based trust model domain has a trust relationship based on trust model, based on subjective logic trust model and the basic behavior of fuzzy logic-based trust model.

However, there are some problems needing to be resolved as follows:

1) Without the descriptions of characteristics in online auction, the models are incapable to predict the transactions

behavior of customers and to solve the negative impact of malicious behavior on trust assessment.

2) With only simply collecting of the reputation feedback, the evaluation process is unable to be examined.

3) By filtering the multidimensional character of credibility, the comprehensive assessment cannot be achieved.

4) Without effective fraud prevention mechanism, the models are vulnerable to malicious behavior. It may lead to inaccuracy of trust evaluation.

5) The subjective impacts of different evaluators with different positions are usually neglected

In order to resolve above problems, we present a multi-viewpoints trust model based on the previous research. By exploiting the business relationships between auctioneer, the bidder and the third party/auction website operator, we propose a comprehensive approach with consideration on the factors of online auction. Based on an extensive discussion and calculation of factors on trust degree evaluation, the recent credibility, auctioned object assessment, behavior analysis etc. are investigated synthetically.

III. MULTI-VIEWPOINTS TRUST MODEL

Online auction mainly includes three kinds of participants, namely auctioneer, bidder and third party/auction website operators. Each participant attends the auction in different ways. In this regard, it is necessary to evaluate different participants separately. The different parameters in the models are taken into consideration.

Recent credibility is a specific parameter to motivate users to be honest. Their partners may make assessments according to it. Meanwhile, it is also a specific parameter for iterative calculation. Most of current trust models consider it as an important parameter. Recent credibility can be expressed as $\tau_{t-1}(u)$, means user U's credibility at time t-1. Table 1 below shows the evaluation parameters of trading entity.

TABLE 1 THE EVALUATION PARAMETERS OF TRADING ENTITY

Trading Entity	**Common test parameters**	**Special test parameters**
bidder	Recent credibility, Reputation feedback, t reputation of graders, time weight, transaction value	Behavior analysis
auctioneer	Recent credibility, Reputation feedback, reputation of graders, time weight, transaction value	Assessment auction
third party/auction website operators	Recent credibility, Reputation feedback, reputation of graders, time weight, transaction value	website quality assessment

Reputation feedback refers to credibility assessment made by graders to his partner based on the subjective experience. There are many factors related to the credibility in online auctions. Specific settings could be made on the requirement of the transaction entities, such as price, service quality, order processing, delivery time and other factors. Users give a specific evaluation according to each key factor. Assumed that $c = \{c_1, c_2, \cdots, c_n\}$ is the key factors for the credibility, c_i stands for the key factor. U stands for the user. The reputation feedback of *u* made by *v* assumes to be f (*v*, *u*), then f (*v*, *u*) is the n-dimensional vector of $c_1, c_2, \cdots, c_n$.

$$f(v,u) = (f_{c_1}(v,u), f_{c_2}(v,u), \cdots, f_{c_n}(v,u)) \tag{3}$$

$$f_{c_i}(v,u) \in [-1,1] \tag{4}$$

N (u) is the trading partners of U, if *x* is one of the partners of *u*, then $x \in N(u)$. Average reputation feedback can be expressed as follows:

$$\bar{f}(x,u) = \frac{\sum_{i=1}^{|c|} W_{c_i} f_{c_i}(x,u)}{\sum_{i=1}^{|c|} W_{c_i}} \tag{5}$$

Among them, $|c|$ stands for the base of credibility key factors, while $f_{c_i}(x,u)$ means the reputation feedback of *u* made

by *x* under the *i*th key factor c_i, $W_{C_i} \in [0,1]$ is the weight of credibility key factor set by system.

The reason for considering reputation of graders is to avoid impact on credibility assessment by reputation slander, credibility fraud and other malicious behavior. It can be expressed as $Cr[\tau_t(x)]$, the substantial of which is the credibility of the user who submitted feedback. More credibility of this user means bigger weight of the reputation feedback, which can be expressed as:

$$Cr[\tau_t(x)] = \frac{\tau_t(x)}{\sum_{y \in N(u)} \tau_t(y)} \tag{6}$$

Where $\tau_t(x)$ stands for the credibility of the user X, $\tau_t(y)$ represents the sum of credibility of all users.

As a dynamic variable, credibility does not keep unalterable. The changing of user's behavior will lead to the fluctuations of credibility, so that credibility should not be simply calculated cumulatively. Thus, we have to take time weight into account. Assume $t_x \in [t-1, t]$ to be the transaction time, ρ is the time weighting factor, $0 < \rho < 1$, $\rho(t_x, t)$ is the reputation feedback of *u* made by *x* during the time of f (*v*, *u*), which means the time weight of reputation feedback. The closer of t_x to *t*, the greater weight of reputation feedback *u* will get.

$$\rho(t_x, t) = \rho^{t-t_x} \tag{7}$$

The value of the transaction is another important parameter, greater value always means more risk, and it will be more difficult to establish trust between the two parties. Supposing P(*x*, *u*) as the value of deal, the weight of transaction value will be:

$$W[P(x,u)] = \frac{P(x,u)}{\mu} \tag{8}$$

μ is standing for the minimum value of transaction set by system which is necessary to meet the conditions of insurance claims. Because the current online transaction sale price is about 200 Yuan (RMB), in this article we just set it as 200.

Behavior analysis is an extremely important assessment parameter for evaluating the credibility of tenders. The behavior of tenders demonstrated in the auction will directly affect the assessment of them by their partners as well as their rivals. According to the bidding rules of tenders, it can be divided into good faith auctions and auction fraud, which may lead to different behaviors of tenders. In terms of distance-based outlier detection method, variables, inter alia bid frequency, bid amount, bid time could be useful to identify auction fraud. In this connection, it can further enhance the accuracy of credibility evaluation. In this article, we use the method of Distance-based Outliers Detection to introduce specific operations.

This operation takes the bidding frequency, bidding amount, and bidding time as the detection variable to be recognized from fraud behaviors, which further improve the accuracy of trust evaluation.

To do the following:

1) Standardization dataset: to make the bidder transactions dataset standardized, to overcome the impact from the different units, measure of distance calculation. $\bar{x}_j$ and S_j are the *j*th attributes mean and standard deviation.

$$\bar{x}_j = \frac{1}{n}\sum_{j=1}^{n} x_j \tag{9}$$

$$\delta_j = \sqrt{\frac{1}{n-1}\sum_{j=1}^{n}(x_j - \bar{x}_j)} \tag{10}$$

Assumes, there are *i* objects, j attributes. x_{ij} is the value of the jth attribute to the ith object, standardized dataset is:

$$x_{ij}^{*} = \frac{x_{ij} - \bar{x}_j}{\delta_j} \tag{11}$$

2) The establishment of distance matrix: After standardization dataset, to use the Manhattan Distance Formula, to calculate the distance d_{ij} between two objects, to accumulate the distance between each object and other objects, to form the distance matrix R.

$$d_{ij} = \sum_{k=1}^{m} \left| x_{ik} - x_{jk} \right| \tag{12}$$

Among them, *m* is the dimension of data objects.

$$R = \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1n} \\ d_{21} & d_{22} & \cdots & d_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ d_{n1} & d_{n2} & \cdots & d_{nn} \end{bmatrix} \tag{13}$$

3) Distance-based Outliers Detection: P_i is the sum of the *i*th row of matrix R, the bigger of P_i, it shows that the *i*th object is far distance to other objects. It may be isolated point.

$$P_i = \sum_{j=1}^{n} d_{ij} \tag{14}$$

$$\overline{P} = \frac{1}{n} \sum_{i=1}^{n} P_i \tag{15}$$

If $P_i > 2\overline{P}$, the *i*th object is outliers.

$K_{t-1}(u)$ is standing for the conclusion of behavior analysis at the time of *t-1*.

$$K_{t-1}(u) = \begin{cases} 1 & P_i < 2\overline{P} \\ 0 & P_i > 2\overline{P} \end{cases} \tag{16}$$

The assessment of good is a key factor, which affects the transaction, so that we take it as a parameter to calculate the credibility. The auctioneer and third parties can not examine whether the auction item is the same as the description of bidder before the accomplishing of deal, which enhances the concerns of them. Therefore, it is helpful to increase the confidence of auctioneer and the third parties with a view of taking auction items of previous transaction into consideration. The assessment of auction item of *X* can be expressed as:

$$E_x = \begin{cases} 1, & \text{truth} \\ 0, & \text{false} \end{cases} \tag{17}$$

In the view of above, the similarity between the assessment of U's goods provided by *X* and the description of goods can be expressed as:

$$w[E(x,u)] = \frac{sim[\mathrm{E}(x,u)]}{\eta} \tag{18}$$

Therein, η stands for the similarity of the assessment and its description set by the model. In this article, we just set it as 50%, namely η =50%

$$\overline{sim}[E(x,u)] = \frac{\sum_{x=1}^{|N(u)|} w[E(x,u)] sim[\mathrm{E}(x,u)]}{\sum_{x=1}^{|N(u)|} w[E(x,u)]} \tag{19}$$

Among them, $|N(\mathrm{u})|$ stands for the base of the assessment users.

Assessment of websites quality is a parameter proposed mainly for the third party/auction websites, because the service, protection measures as well as transaction records it provides to the users will have a direct impact on the credibility of users. Meanwhile, it can also be an important standard for the users to select third-party/auction websites. Therefore, to assess the websites quality is of significance to examine the credibility of the third party/auction websites.

According to requirements, we assume $S=\{S_1,S_2,\cdots,S_n\}$ to be the key factors of websites quality, S_i to be the *i*th key factor, $\mathrm{SQE}_{\mathrm{S_i}}$ to be the assessment of websites quality affected by the *i*th key factor. Then, the average assessment of the website quality can be expressed as:

$$\overline{SQE}=\frac{\sum_{i=1}^{|S|}w_{S_i}SQE_{S_i}}{\sum_{i=1}^{|S|}w_{S_i}} \tag{20}$$

Therein， w_{S_i} stands for the weight of the key factor of website quality.

- Bidder in online auction

Considering the activities of auctioneer in online auctions, the following factors should be examined during the assessment process: the recent credibility, the reputation feedback, the reputation of graders, the behavior analysis, the time weight, and transaction value.

To conclude, the model should be：

$$\tau_t(u)=\begin{cases}\alpha\tau_{t-1}(u)\\ +\beta\lambda_1 e^{\sum_{x\in N(u)}W[P(x,u)]\cdot C_r[\tau_{t-1}(x)]\cdot\rho(t_x,t)\cdot}\\ \cdot\bar{f}(x,u)\cdot K_{t-1}(u) & N(u)\neq 0\\ \tau_{t-1}(u) & N(u)=0\end{cases} \tag{21}$$

Among them, α means the impact of recent credibility on user *u*, while β means the impact of reputation feedback provided by U's partner, λ_1 means the impact of behavior analysis of *u*.

- Auctioneer in online auction

The factors with the activities of the bidder in online auction should be considered in credibility assessment. They include the recent credibility, the reputation feedback, the time weight, the transaction value, the assessment of goods and the credibility of graders. The top 5 factors are the same as those of bidder.

Based on above elements, the computational model should be：

$$\tau_t(u)=\begin{cases}\alpha\tau_{t-1}(u)\\ +\beta\lambda_2 e^{\sum_{x\in N(u)}W[P(x,u)]\cdot C_r[\tau_{t-1}(x)]\cdot\rho(t_x,t)\cdot w[E(x,u)]}\\ \cdot\bar{f}(x,u)\cdot\overline{Sim}[E(x,u)] & N(u)\neq 0\\ \tau_{t-1}(u) & N(u)=0\end{cases} \tag{22}$$

Among them, α means the impact of recent credibility on user u, while β means the impact of reputation feedback provided by U's partner, λ_2 means the impact of assessment of U's auction items on himself as bidder.

- The third party/auction website operators in online auction

The factors with the activities of the third party/auctions websites operators in online auction to be considered in credibility assessment include recent credibility, reputation feedback, credibility of graders, the weight of time, the transaction value, assessment of website quality. The top 5 factors are the same as those of auctioneer or bidder.

Based on above elements, the computational model should be：

$$\tau_t(u)=\begin{cases}\alpha\tau_{t-1}(u) & \\ +\beta\lambda_3 e^{\sum_{x\in N(u)} W[P(x,u)]\cdot C_r[\tau_{t-1}(x)]\cdot\rho(t_x,t)} & N(u)\neq 0 \\ \cdot\ \bar{f}(x,u)\cdot\overline{SQE} & \\ \tau_{t-1}(u) & N(u)=0\end{cases} \tag{23}$$

Among them, α means the impact of recent credibility on user u, while β means the impact of reputation feedback provided by U's partner, λ_3 means the impact of quality assessment on user U as the third party/auction website.

IV. NUMERICAL ANALYSIS

We create a simulation environment of multi-angle trust model by using MATLAB 7.0. The partial data of simulation experiment are shown in Table 2.

TABLE 2 THE PARTIAL DATA OF SIMULATION EXPERIMENT

Transaction partner	1	2	3	4	5
Transaction value	2	4	19	10	23
Weight of grader	0.5	0.6	0.8	0.1	0.3
Weight of reputation feedback under C_1	0.1	0.7	0.6	0.4	0.3
Reputation feedback under C_1	-0.3	0	0.1	0.5	0.2
similarity assessment	0.4	0.6	0.7	0.2	0.3
similarity assessment weight	0.8	1.2	1.4	0.4	0.6
Assessment weight under S_1	0.4	0.5	0.4	0.9	0.8
Grade under S_1	0.1	0.2	0.5	0.8	0
Transaction partner	6	7	8	9	10
Transaction value	11	9	27	16	27
Weight of grader	0.4	0.6	0.3	0.8	1
Weight of reputation feedback under C_1	0.4	0.2	0.9	0.2	0.8
Reputation feedback under C_1	0.7	-0.5	-0.9	-1	1
similarity assessment	0.1	0.5	0.4	0.1	0
similarity assessment weight	0.2	1	0.8	0.2	0
Assessment weight under S_1	0.1	0.2	0.3	0.7	0.8
Grade under S_1	1	-0.3	-0.5	-1	-0.1

The feasibility can be examined by the variations data of different participants in online auctions during a certain period. Auctioneer, in this article mainly refers to person in good faith.

In order to facilitate the calculation of the model, this paper presumes the value of α, β, λ_1, λ_2 and λ_3 as 1. The recent credibility has a uniform distribution between [0, 10] with an initial trust as 0. The transaction partner $N(u)=10$. In this paper we examine the change of credibility of certain auctioneer, bidder as well as the third party/online auction website within 30 days. In addition, the behavior analysis of auctioneer does not include fraud behavior, that is $K_{t-1}(u)=1$. Fig. 1 shows the results of simulation experiment.

Results can be drawn from the experiment: in the initial stage, the recent credibility should be set to 0 due to the initial status of online auction participants. With the process of time, the credibility starts to change, since he participates in online auction and gets reputation feedback. Different participants could get different results in the same period of time, due to the different references selected. The conclusions of the credibility assessment present upward trend due to the special design of model. Because this can avoid identity fraud by re-registering new identity while discarding old one. Despite of credibility of participants, the credibility will remain unchanged, significantly or slightly increase, because if there is diminishing, the user may discard the old one and re-register as a new identity to continue fraud activity once his credibility reduces or is even below zero after the fraud activity. The kind of design makes the credibility of such user higher than new identity. Thus, it is not necessary to discard an old identity to participate online auction, the credibility of which is higher than a brand-new one. By this way, void the situation of discarding reputation documents.

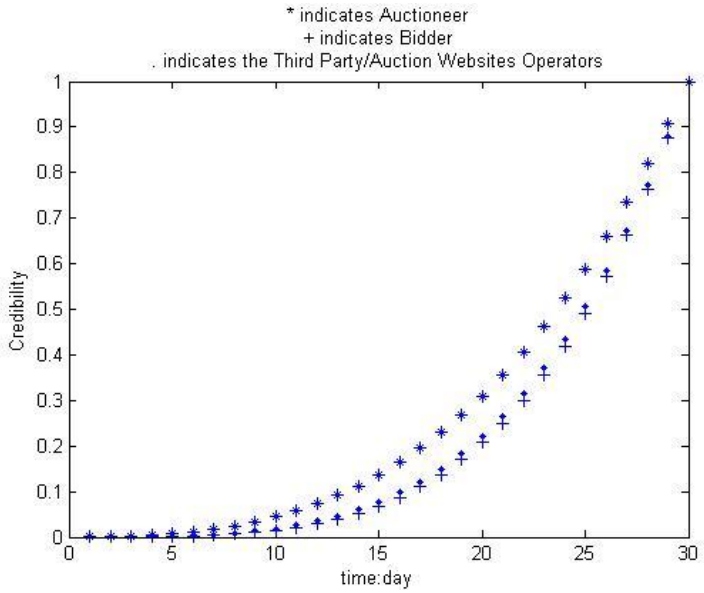

Fig. 1 The trust variation of online auction participants within 30 days

V. CONCLUSIONS

Compared with other trust models, the suggested multi-viewpoint online trust model is more specific. The trust model comparison is shown below in Table 3. It is suitable to credibility assessment of different participants. By considering different roles, the model can greatly improve the accuracy and integrity of assessment.

TABLE 3 TRUST MODEL COMPARISON

Trust Mode	**modeling method**	**model parameters**	**fraud prevention**
Cumulative Trust Model	Cumulative, recursive	reputation feedback	No
Average Trust Model	Cumulative, Average	reputation feedback	No
Sociological Theory-Based Trust Model	Sociology	situation, time	No
Statistics-Based Trust Model	Probability Theory	positive events, negation events	No
Probability-Based Trust Model	Semantic Variable	reputation feedback, situation	No
Semantic-Based Trust model	Significant	reputation feedback, time, Recent credibility, reputation of graders	Yes
Uncertainty Theory-Based trust Model	Artificial Intelligence	reputation feedback	No
Grid-Based Trust Model	Grid	trust domain	Yes
Mulit-Viewpoints Trust Model	Artificial Intelligence, Probability Theory, Sociology, etc.	recent credibility, reputation feedback, reputation of graders, time weight, transaction value, behavior analysis, assessment auction, website quality assessment	Yes

Compared with other models, the existing trust model has many problems, and has been described in Section II. Although the model has been proposed in this paper, and it has its advantages, it still has some defects. There are still several points that should be considered for further study:

1) This article does not consider the impact on credibility assessment by user's fraud activity, which needs further study

and analysis in the future;

2) There is a lot of computing works in this model. The final outcome of the model is bigger, which needs standardized processing in order to facilitate the comparison and evaluation of credibility.

3) Some of the qualitative concepts must be transformed to quantitative concepts during the trust computation. Therefore, how to make the qualitative simulation and quantitative simulation combine reasonably is an important subject in online auction.

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